Proceedings of the Project Workshop (GT/1010-00-04):

Early Warning, Forecasting and Operational Flood Risk Monitoring in Asia

(Bangladesh, China and India)

December 2-6, 2002, Sioux Falls, SD, USA

United Nations Environment Programme

Division of Early Warning & Assessment

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UNEP

Preface

During the 1990s many severe floods occurred in South and East Asia. These floods caused many casualties and significant destruction of infrastructure. These floods seem to be occurring more frequently. Increased populations in this region and the movement of human population into flood plains have increased the vulnerability of these populations to the threat of floods. Following the disastrous floods in the Yangzte and Ganges/Brahmaputra river basins, the German Government agreed to fund the study of Early Warning, Forecasting and Operational Flood Risk Monitoring methodologies in Asia with a particular focus on Bangladesh, China and India.

United Nations Environment Programme Global Resource Information Database (UNEP GRID) Sioux Falls has been active in the study of human vulnerability to hazards, has supported the study of international river basins through its collaboration with Oregon State University on the Atlas of International Freshwater Agreements, and supports the development of information sharing through Global Spatial Data Infrastructure Clearinghouses. The U.S. Geological Survey (USGS) EROS Data Center International Program in cooperation with the National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS), the USGS Division of Water Resources (WRD) and U.S. Agency for International Development (USAID) have been investigating remotely sensed information and Geographic Information Systems as tools for flood monitoring in Africa for many years. These tools are appropriate for use in Asia. The sharing of information among countries is critical to all aspects of early warning, forecasting and monitoring of floods. UNEP GRID Sioux Falls is the lead agency within UNEP for applications of remote sensing and spatial analysis technologies. These technologies are crucial to better forecasting and monitoring flood events, and for assessing the effects of floods on human populations and the environment.

UNEP GRID Sioux Falls assembled a team of scientists from India, China, Bangladesh, and the US to prepare an overview of the issues and technologies related to floods in the region during phase one of the project. During phase two, scientists from India, China, Bangladesh and Cambodia were invited to UNEP GRID Sioux Falls to evaluate the report and the proposed technologies. A scientist from the Mekong River Commission was requested to share his experiences in the sharing of information among the many countries in the Mekong River Basin. The workshop was held from 2-4 December 2002. The report was reviewed. The scientists from China, India, Bangladesh and Cambodia presented the state of flood forecasting and monitoring in their counties. On 5-6 December 2002, the team of scientists visited the National Weather Service, USAID and the USGS Water Resources Division to discuss developing technologies of relevance to improved flood forecasting, monitoring and risk assessment in Asia.

Dr. SHI Hua, Chinese Academy of Sciences, Beijing China, Dr. Ramesh SINGH, Department of Civil Engineering, Indian Institute of Technology Kanpur, Kanpur-208 016 (U.P.), India and Mr. Nazmul HOSSAIN, Bangladesh University of Engineering and Technology, Dhaka, Bangladesh compiled the Project Report with assistance from the USGS EROS Data Center International Program Hydrology staff.

Staff from many organizations assisted in making the workshop a success. We would particularly like to acknowledge the delegates from South and East Asia, who provided information concerning flood forecasting, monitoring and risk assessment in the region. Dr. LIU Zhiyu and Ms. LI Yan from the Bureau of Hydrology, Ministry of Water Resources in Beijing represented China. Prof. Raj Pal SINGH from the University of Roorkee in Uttranchal, and Mr. Mahesh K. JIWRAJKA from the Ministry of Environment and Forests in New Delhi represented India. Emaduddin AHMAD from the Institute of Water Modeling, in Dhaka represented Bangladesh. The willingness of Mr. Thanongdeth INSISIENGMAYto represent the experiences of the Mekong River Commission in Phnom Penh were greatly appreciated.

Staff from the US agencies associated with Flood Monitoring and Water Resource Management shared their experiences with the Delegates. Dr. James VERDIN, Dr. Saud AMER, Mr. Michael BUDDE, and Mr. Guleid ARTAN from USGS EROS Data Center, International Program discussed their experiences in Africa and the Mekong River Basin and their plans for the Asia Flood Net. Mr. Curt Barrett and Jennifer Lewis from the NOAA NWS described forecasting methodologies in use in the US and their experiences in the support of international activities. Dr. Sezin TOKAR and Mr. Dan DEELY from USAID discussed their international activities in water resource management with a particular emphasis on Asia. Ms. Anna Lenox, Mr. James PETERS, Mr. Robert MASON, Ms. Candace BOSTWICK, and Mr. William BARTLETT from USGS WRD National Center in Reston discussed the cooperative nature of the water resource monitoring in the US with a focus on real time access to stream flow information and emerging technologies for monitoring stream flow.

Staff from UNEP/DEWA – North America, USGS, EROS Data Center, Dr. Ashbindu SINGH, Dr. Eugene A. FOSNIGHT, Ms. Jane S. SMITH, Mr. Mark ENRSTE and Ms. Kim GIESE, facilitated the compilation of the review report and coordinated the workshop and this report summarizing the workshop and the recommendations resulting from the workshop with assistance from Dr. SHI Hua.

Dr. Ashbindu Singh
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Disclaimers

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Recommendations

The following recommendations would directly contribute to the development of a long-term strategy for early warning of floods, but it is acknowledged that to meet these recommendations is a long-term activity that must be approached incrementally. A plan to move toward addressing these issues serves as the concluding recommendation. The issues are broadly organized as Regional and National issues, even though all issues have components of both.

Issues and Recommendations

Regional Issues

Issue 1: More complete and timely sharing of meteorological and hydrological information is needed among countries within international drainage basins.

- A data sharing policy should be established between different agencies, organizations and nations to allow information to effectively be used for basin wide early warning and risk assessment.
- Develop a web site of the global basins to be continuously updated with national meteorological and hydrological data.
- Maintain long term archive of data for use in validation and model refinement to improve rainfall and discharge estimates and forecasts.

Issue 2: Technology should be shared among all agencies involved in flood forecasting and risk assessment both in the basins and throughout the world.

- Maximize resources and expertise on a regional level through consultation, conferences and meetings among regional water resource experts and managers.
- Strengthen cooperation between developed countries and developing countries in technologies relevant for monitoring, forecasting, and risk assessment of floods.
- Technical cooperation projects for capacity building, including dissemination of available technology, should be undertaken.

Issue 3: Need improved rainfall and snow pack estimates, better and longer forecasting of rainfall, and more precise and accurate elevation and watershed information.

- Create hydrologically-correct elevation data for deriving accurate watershed boundaries and flow information for use in hydrologic models.
- Improve rainfall estimation using various techniques such as integrating the rain gauge network with those based on meteorological radar and meteorological satellite images.
- Monitor snow pack using satellite remote sensing data validated by ground measurements.

- Use historical archive of stream and meteorological information to validate and improve rainfall and discharge estimates and forecasts.

Issue 4: Better gauging of rivers, collection of meteorological information and mapping of channels is needed.

- Doppler shift radar should be deployed to better monitor rainfall.
- Enhance the hydrological-meteorological network in vulnerable areas susceptible to flash flooding.
- The density of meteor-hydrological stations, especially related to river flow and measurements of runoff from streams and rivers, should be substantially increased.
- Hydro-meteorological stations should be linked with robust and efficient communications, including the use of satellite telemetry for critical or remote sites, to provide real-time transfer of data among local, regional and central stations.
- Better mapping of actual stream channels and river banks, including land slide and erosion potential.
- Investigate alternative measurement equipment, such as radar and ADCP for monitoring stream flow.

Issue 5: Better and current information about human populations, and infrastructure, elevation and stream channels needs to be incorporated into flood and risk assessment models.

- Collect and maintain information concerning the locations of human populations, infrastructure and emergency response personnel.
- Use information collected to minimize risks and damages during flood event, to maximize relief efforts during and after flood events, and for scenario testing to minimize risks from future flood events.
- Use hydrologic and meteorological information for general water resource management beyond flood forecasting.

Issue 6: Better sharing of information is needed between forecasters, national agencies, relief organizations and the general public.

- Develop an integrated flood forecasting, flood management and flood preparedness system with participation from all stakeholders.
- Identify weak links and regularly check lines of communication to maximize lead time for flood forecasting.
- Prepare and communicate an effective outreach mechanism to communicate the changing status of floods and make evaluations to update actions.
- Prepare flood hazard maps to effectively show areas under threat of flooding for different flood stages and actual inundated lands.

- Train people to be self-reliant, proactive and ready before the onset of floods. A village inter-protection forecasting plan should include staff to gauge flood levels, flood marking, record keeping, evacuation routes, etc.

Issue 7: Need improved structural and non-structural activities to minimize risks.

- Make provisions to regulate water flow for flood moderation on the river, added to existing provisions for irrigation and hydrological power. Storage resources on the rivers may be necessary to accomplish this goal.
- Monitor in real-time the dangerous levees, dikes, banks, reservoirs etc. and transfer video by satellite.
- Address frequent failures of flood embankments in developing countries through technical design planning, construction and careful maintenance at appropriate levels.
- Develop adequate regulatory measures with legal support for flood plain zoning in developing countries, especially with high population growth rates. This will help to check indiscriminate and unplanned development in flood plains.

Issue 8: Need spatial models integrating precipitation, stream monitoring, infrastructure, watershed characteristics, human population, emergency response to better minimize flooding, minimize risk to human populations, minimize risk to infrastructure, and maximize accuracy and effectiveness of forecasts.

- Develop improved geo-referenced watershed data and GIS-based hydrological models to enable estimation of water balances and flows with the participation of representative professional institutes of each country.
- Develop an integrated solution in which rainfall estimation and hydrologic forecasting are combined for flood forecasting on a continuing basis.
- Geo-environmental appraisal of the likelihood of riverbank erosion, slope instability, debris flow material and glacial lake outbursts should be undertaken to forecast potential risks and before making a decision to install new infrastructures, such as dams, bridges, roads, levees and impoundments.
- Develop a coastal boundary from the Bay of Bengal oceanographic and atmospheric data to support coastal flood forecasting.
- Prepare a strategic plan to combat floods using meteorological, satellite and other remote sensing data.

Discussion from summary meeting

At the midpoint of the project prior to departure of the delegation to Washington, DC, the delegation met and provided recommendations regarding "what next?" The summary of this discussion follows:

India: Projects need to be technical in nature. Structural facilities and infrastructures need to be national in scope otherwise external resources get spread too thin. External funders need to see national commitments to problems. Projects must have a defined end point.

India: Donors are very interested in international and coordinated solutions to problems. Flood forecasting is a classic project for international activities that require strong national commitment. Multi-donor consortiums from the Netherlands, Japan, Germany, the US, and others, are providing 5M to 25M for national capacity building projects. Environmental concerns related to deforestation/land cover changes have an impact on floods and should be addressed.

MRC: The convening of a flood forum with participants from many agencies would provide an opportunity to meet and know counterparts in all basin countries in many areas of monitoring, and forecasting. Forums provide an inexpensive and effective means of disaster preparedness and assessment of lessons learned. These meetings can yield efforts to promote the development of infrastructure and demonstrate national interests. The proposal should come from the countries. A recommendation for this meeting should be the circulation of a project profile among the countries, to include a recommendation for a workshop to write a proposal for international funding of coordinated national projects.

GRID-SF: The Global Environment Facility and Gesellschaft für Technische Zusammenarbeit (GTZ) are possible sources of funding via UNEP for an international/regional cooperative project.

Bangladesh: GIS and remote sensing models and information for a regional system are an important contribution from international organizations. Models should be national in scope and be tailored to national requirements. Flood management is only one facet of the problem; agricultural water needs are also important (rainfall forecasting for flood and agriculture). Climate change and oceanic studies have important long-term consequences. An open system for sharing information is critical, but within the political structure these changes are slow to happen. For example, intentional breaching of levees/roads, can provide an opportunity to minimize impact on human population through controlled flooding. The water supply in Bangladesh is very high, among the highest in the world, but this does not mean that the water is available when it is needed. International cooperation is critical.

China: Long series of data are very important for both research and application. Water issues vary by regions within countries; in China there is too much water in the south, and too little in the northwest. Environmental issues are receiving increased attention. Floods need improved rainfall forecasting. The national government will fund flood forecasting system collection, decision support, forecasting system, and distribution system. The use of radar information in combination with present systems can maximize assessment and predictive options. Physically-based models are important and national models exist that are better designed for Chinese landforms and climatic conditions. Interest is primarily in satellite rainfall estimates to supplement existing methodologies. There is a need for six-month predictions for rainfall estimates for drought/agricultural needs. Land use change related to environmental impact, including erosion/sedimentation studies, is important.

China: Improved hydraulic models are needed and can be provided by the national government. Opportunities exist for joint development of models. Key project for IPPC climate change is needed. A workshop needs to be held for research methods to enhance regional cooperation, and to establish regional flood forecasting.

USGS: Rainfall estimation improvement continues with new research at NOAA and the University of Arizona and elsewhere integrating stations, infrared, and radar. NOAA has implemented modular approach for model implementation involving data availability and nature of basin. A suite of models is possible for drought and regional long-term forecasts for agricultural and electric power requirements. There is a need for more understandable rainfall estimates and for bounds around estimates. Environmental research is key to the Center’s research and application activities including possible forecasts of land use change based on projected agricultural management practices and population growth.

India: What are requirements for minimum river flood?

USGS: US water rights are based on senior rights: who was there first? The environment has the oldest rights and therefore has first demand on the water, so sufficient water needs to be released to maintain the ecological system.

MRC: There are significant resources in the region. It is important that these resources are shared to better forecast flood and water availability in general. It is important to share not only throughout region but also across disciplines within the country and region. It is important to inform our counterparts in the region and nations of within regional and national organization activities.

Summary Recommendations

Convene a forum in the region of regional water resource managers and experts to continue dialogue with an initial focus on issues one and two. Proposed tasks of the initial meeting should include:

1) **Promote colleague-to-colleague communication.**
2) **Establish baseline requirements for sharing data, expertise and forecasts among countries.**
3) **Identify data gaps that can effectively be complemented by international support, such as improved satellite-derived rainfall estimates and drainage base delineation.**
4) **Prepare proposal for funding to support these requirements.**
5) **Have strawman draft of proposal crafted by the delegates ready for review and revision at the meeting.**
6) **Asia Flood Net could serve as initial focal point for proposed regional activities.**

Follow-up meetings of the Forum should identify shared requirements and opportunities for targeted funding for national issues.

Summary of Discussions

This summary serves as a synthesis of the ideas shared during the course of the five-day workshop involving staff from Bangladesh, China, India and the US. This summary is constructed from notes taken during the meeting and from information extracted from each of the presentations. Please accept our apologies in advance for the extraction of large segments of the presentations and for any mistakes introduced. Please refer to the papers and presentations included on the CD-ROM for the definitive statements of the participants.

Flood monitoring, forecasting and risk assessment represents only one extreme of the total water resource management picture. The other extreme is represented by drought and water shortages. Between these extremes are many competing requirements for water. Floods and droughts are not inherently disasters. They only become disasters when human populations are affected.

China

In East China, rainstorms in combination with coastal storm surges primarily cause flood disasters, whereas in the west snow and glacier melt and local storms cause mixed-type floods. There are 18,459 hydrometric stations in China, of which 7,055 report flood information and 1,000 issue flood forecasts. The stations report to the National centre in less than one hour and flood warnings are issued to the public through media and local government. Flood prevention has both structural and nonstructural aspects. Structural methods include levees, dams, and flood retaining, diverting and retarding areas. Nonstructural measures to reduce risk include zoning, hydrological telemetering, flood forecasting models and telecommunications.

China uses a distributed physically-based hydrologic model incorporating elevation, soil and land use. A modular structure was adopted to facilitate adding and evaluating new models. A large suite of models has been implemented and evaluated. Models can be tailored and calibrated to meet conditions for specific watersheds or sub-watersheds. The flood forecasting system supports flexible real-time processing, uses a graphical and tabular interface for interactive forecasting, and efficiently processes large amounts of data.

Conclusions:

- Early warning can empower communities threatened by impending disasters
- Warning must be given in good time, be precise and prompt, and should convey reliable information
- Education, telecommunication systems, multi-disciplinary approaches and networking with other organizations must be strengthened in order to enhance early warning efforts
- A new-generation flood forecasting system shall be developed, which is general, comprehensive, user-friendly

- Further development is needed to design, implement and test new hydrologic and hydraulic models
- Better runoff prediction and reservoir operation modules are needed
- Better visualization tools will support more effective use of information collected and modeled

Bangladesh

Likely no country in the world is more vulnerable to flooding and likely no country in the world has as so little control over the floods. The people of Bangladesh are very vulnerable to flooding. The population density is very high. The land is very flat. The monsoon rains and typhoons can be very intense. In a severe monsoon rain event, up to 70 percent of Bangladesh may be inundated. Up to 25 percent of the country can be reached by a typhoon generated storm surge from the coast. In 1970, 300,000 people lost their lives in a storm surge. The importance of providing sufficient warning to allow local governments an opportunity to respond effectively to the threat of flooding cannot be over stated.

The present flood forecast model is used to create 24-72 hours forecasts. Inputs to the models include 187 rivers, 207 link channels, 37 rainfall stations, 58 water level stations, and 76 forecast stations in Bangladesh, and 11 water level stations and 8 rainfall stations in India. The water level is forecast at 2,400 points. The flood maps produced are validated using remotely sensed images.

Many of the worst floods are due to storm surge or to monsoon rainfall in the Indian hills adjacent to the flood plain. Effective flood forecasting requires incorporation of information from adjacent lands in India. Bangladesh also needs improved information from upstream in the Ganges-Brahmaputra Basin, such as more representative rainfall data, actual river cross section, snow melt information, soil profile data, more intensive land use and crop coverage data, and water demand and upstream withdrawal. The need for upstream data is to forecast when and how much water will enter Bangladesh. Spatial information, such as elevation, drainage basins, land cover and infrastructure, can be more generalized for basin-wide coverage. Conversely, the spatial data for Bangladesh must be very accurate, precise and current to support effective flood forecasting, risk assessment and early warning. Maps and data representing infrastructure, human populations, and water courses must be current to be effective.

Global climate change has potential serious consequences for Bangladesh. Predicted local changes include sea level rise, increase in evaporation, increase in snowmelt in the Himalayas, decrease in precipitation in the dry season, increase in precipitation during the monsoon and prolonged monsoon. These changes could incur the following consequences: an increase in salinity intrusion, drought, impact on agriculture and fisheries, increase in flooding intensity and submergence of coastal areas.

Development needs for Ganges-Brahmaputra-Meghna Basin 4-15 days forecast model, erosion prediction and tidal surge forecasting:

- Meteorological rainfall forecast in the drainage basin
- Distributed hydrological model generating runoff boundary for the hydrodynamic model to support flood forecasting and water management
- 2-dimensional morphological model for erosion prediction
- Prediction of wind speed and direction
- Rainfall forecast in the drainage basin
- Basin hydrological model to generate boundary data for morphological model
- Sediment transport
- Bay of Bengal model for generation of tidal boundary
- Oceanographic model to generate deep sea boundary for Bay of Bengal hydrodynamic model
- Prediction of wind speed and direction
- Prediction of cyclone track
- Model-GIS interface for generating flood maps (depth, area, duration)
  Use:
  - Flood plain resources management
  - Flood management/disaster management
  - Provide protective measures
  - Save life and property by providing sufficient lead time for evacuation/relocation
  - Minimize damage, e.g. early harvesting of crops, infrastructure protection

India

The India flood forecasting service was initiated by the Central Water Commission in 1958. A network of 157 flood forecasting stations was established in major and interstate river basins. Of these, 80 flood forecasting stations are on the Ganges and 27 are on the Brahmaputra.

The steps in the flood forecasting and warning system are to 1) collect data, 2) transmit results, 3) analyze data and compute forecast, and 4) disseminate forecast. Data collected includes river water level, river discharge, rainfall and other precipitation. The data are transmitted using wireless, telephone, fax, satellite, telegraph and telex. The data are analysed and forecasts are computed using simple correlation, co-axial correlation, Muskingum method and successive routing through sub-reaches mathematical models. The accuracy of the flood forecasts is calculated and analyzed for each forecast station.

Providing absolute protection to all flood prone areas for all magnitude of floods of different probabilities of occurrence is neither practically possible nor economically viable. Hence, a practical approach in flood management is to provide a reasonable degree of protection, against flood damage at economic costs through a combination of structural and non-structural measures. Flood plain zoning is needed to ensure that essential services are protected from flooding and to minimize risk to life and property.

The main thrust of the flood protection program undertaken in India so far has been in the nature of structural measures, such as embankments, flood walls, dams and reservoirs, natural detention basins, channel improvement, drainage improvement, diversion of flood waters; and non-structural measures, such as flood plain zoning, and flood proofing. Flood plain zoning aims at disseminating information on a wider basis so as to regulate indiscriminate and unplanned development in flood plains and is relevant both for unprotected as well as protected areas. Flood proofing measures help greatly in mitigation of distress and provide immediate relief to the population. The importance of flood forecasting enables forewarning as a non-structure measure to inform the public as to where the river is going to use its flood plain, to what extent and for how long.

Early warning is extremely valuable in cases of flash floods, which are quite frequent on Himalayan Rivers and their tributaries due to heavy land slides. These are also among the most difficult warnings to provide.

If people living in the flood plains are fully conversant with the system of warning signals, issued from time to time in different situations, messages can be disseminated to the people living in affected areas quickly. If they are fully involved, the loss of life and property can be minimized to a considerable extent.

Mekong River Basin

The Mekong River Basin includes parts of six countries. Wide spread flooding tends to be caused by monsoon rainfalls in Laos, Thailand and Cambodia in the lower basin. The large number of countries sharing flood prone areas requires close working relationships to provide earlier and better warnings to minimize the risks to human populations. The Mekong River Commission (MRC) seeks to integrate the near real-time information provided by the national hydro-meteorological networks in the basin to provide flood forecasts.

The MRC presently uses mathematical models (SSARR, regression, ANN) to provided a three-day flood forecast during the rainy season for more than 20 locations along the mainstream, based on daily data from 37 hydrologic and 22 rainfall stations. Real time, 7-day a week data via improved networks (satellite, GSM, e-mail, radio, etc), including data from China, started in 2002. Rainfall data are summarized by sub-basin and are made available from MRC on the Internet. Forecasts and warnings are disseminated as hydrographs, bulletins, alert levels, flood maps and over the Internet.

Proposed improvements include

- improved monitoring, particularly on tributaries
- improved operational forecasting with streamlined links to national flood forecasting
- indicative forecasting for cultivation planning; how much warning and how accurate
- improved warning and dissemination services
- strengthened real time data collection system (regional and national)
- competence (capacity building and training)

Forecasts are needed both along the tributaries and in the floodplain. The influence of storage reservoirs and other structures needs to be added to models. The communication from the MRC forecasts to partner organizations to the vulnerable communities are the weakest links. This includes the feedback loop where the vulnerable community assesses the effectiveness of the forecasts and warnings. Governance and sustainability require the active participation of affected people, full cooperation of civil society organizations and education and training at all levels.

USGS/WRD

USGS/WRD water offices, over 150 with at least one in each state, serve to support the cooperative programs with the states. About half of the work in the cooperative water program has to do with stream gauging: the remainder is with short-term projects. The cooperative program serves the important effect of justifying and prioritizing activities. Placement of gauging is, in general, a state decision. Some national money is available for gauges of national importance. About 4,200 stream gauges are operated and maintained.

USGS/WRD provides access to streamflow data from 22,600 sites, water levels from over 1,400,000 wells, and chemical data from rivers, streams, lakes, springs and ground water at 338,000 sites. The data are collected in real-time at 8,830 of the stream, lake, reservoir, groundwater and meteorological sites. All of these data are publicly available and can be accessed via the Internet. Daily stream flow condition maps are very popular with the public. Ground and surface data are collected every 4 hours, with plans to go hourly. Ground water monitoring can be used to monitor over pumping (level and salinity), effects of earthquakes.

Data quality assurance is an important role of USGS/WRD. Instruments are calibrated about once a month to detect instrument failure or instrument drift. Sniffer programs are used to detect outliers in thresholds and rates of change. Water quality assessment has about a six month cycle due to requirements for lab studies. Temperature, sediment, conductivity, chlorophyll, and turbidity are starting to be measured *in situ*. Satellite century program is used to “adjust” the data as needed. A data descriptor is used to describe the type of sensor, type of transmission, and format of data. Orchestrating all the data sources is a major activity.

USGS/WRD are investigating radar alternatives for real-time measurement of velocity and depth profiles across streams. Many rivers have very unstable channels and banks. Non-contact measurement of river discharge, depth and velocity of rivers with rapidly changing cross-sections is critical both during a flood to minimize risks to vulnerable populations, but also to remap channels following flood events. For major rivers in flood situations the radar can effectively be flown in a helicopter provided reduced accuracy is acceptable.

NOAA/NWS

The mission of NOAA’s National Weather Service is to provide river and flood forecasts and warnings for protection of life and property, provide dam-break forecasts, and provide basic hydrologic forecast information for the nations’s economic and environmental well being. NOAA uses the best available gauging data collected by USGS/WRD and the best satellite information to model rainfall and to forecast flood events. NOAA cooperates with national and regional agencies to transfer NWS technology to help better forecast flood events.

Rainfall estimates have been available for Southeast Asia since 1998 and for Central Asia since 2002. NOAA is planning to provide rainfall estimates globally starting in 2003. Three-day rainfall forecasts are available for Southeast Asia. Five-day forecasts are desirable. The rainfall estimates are a function of point-sampled data, satellite estimates and hydrologic gauging stations. Only World Meteorological Organization (WMO) stations are used in the model. Many other stations exist. The use of these local data can vastly improve the rainfall estimates. As long records of rainfall estimates are accumulated with concurrent collection of rainfall and stream gauge data, the rainfall estimates can be better calibrated and validated.

NWS River Forecast System uses rain gauge precipitation measurements, radar precipitation estimates, satellite precipitation estimates, stream flow measurements, weather forecasts, climate predictions and snowpack estimates to provide information regarding flash flood watch/warnings, river/flood forecast/warnings, hydropower, water supply, irrigation, recreation, and navigation. The Long-Range Probabilistic River Forecast system uses historical precipitation, temperature, and evaporation data, and current model states to produce mid- to long-range probabilistic worst case/best case forecasts. Flash flood warning systems are in use for targeted basins that use GIS Data, rainfall estimates/forecasts, and hydrologic models to predict flash floods. Equally important are well placed automated upstream sensors and gauges that continuously monitor locally heavy rain or rapid rise in the stream flow.

USGS/EROS Data Center

Ground features, such as roads, can influence the nature of local flooding through channeling and blocking flows. The use of rainfall estimates, gauging data, watersheds, flow direction, infrastructures and human populations in a geospatial model can help to better model the severity of floods, the risk to human populations and potential remedies to minimize risks. Maps can show the extent of flooding provided sufficiently accurate topography and infrastructure information is available.

Most major river systems in the world are international. To better manage these rivers requires better sharing of information. Most countries have national web-based systems, but no regional network exists for sharing information. One mechanism to share information is through a web-based system that would collect, harmonize and model data provided by national networks in a sufficiently timely fashion to be effective for flood forecasting.

Flooding in Asia is typically caused by monsoon related rainfall events. Although floods caused by events such as glacial outbursts are locally very important, snowmelt does not tend to be a major source of flooding. In fact, snowmelt is often a critical source of water during the dry season.

USAID

The USAID/Economic Growth, Agriculture and Trade Water Team and USAID/Office of Foreign Disaster Assistance (OFDA) work closely with USGS and NOAA to minimize risk to vulnerable populations in regard to flood events and drought. Floods, droughts, fires and catastrophic storms are causing more damage, in part because of poor natural resources management. Damages and risks are amplified by deforestation, soil erosion, destruction of wetlands and development in disaster-prone areas. Nearly 40 percent of the world's people live in more than 200 river basins that are shared by more than two countries. Each of these basins would be best served by agreements that describe their shared water resource responsibilities. USAID is active in many areas including 1) aquifer and ground water management; 2) transboundary water management; 3) data/information systems; 4) policy; 5) agriculture; 6) urban, industrial, and energy; 7) ecosystems; 8) hydrometeorology and hydromet forecasting/warning system; 9) disaster planning, prevention, mitigation, and response; 10) flood and drought mitigation and control; and 11) water quality for health. USAID invests about 32 million USD in disaster preparedness with about 52 percent in monitoring and forecasting and about 48 percent in vulnerability assessment.

The vulnerability of those living in risk-prone areas is perhaps the single most important cause of disaster casualties and damage. The number living in "harm's way" is growing rapidly. USAID/OFDA hydro-meteorological mitigation activities in Asia include extreme climate events, flood early warning, coastal storm early warning, climate forecasting, transboundary river forum, flood referencing, Asia Flood Network and enhanced disaster preparedness. The Asia Flood Network is intended to reduce the vulnerability of population to flood hazards in Asia by identifying and filling the gaps in flood/river forecasting and early warning, and by strengthening regional and national institutions hydrometeorological forecasting and early warning.

Appendix A
Agenda

Visit by: Dr. Zhiyu Liu and Ms. Yan Li, Bureau of Hydrology, Ministry of Water Resources, Beijing, China; Mr. Emaduddin Ahmad, Institute of Water Modelling, Dhaka, Bangladesh; Mr. Mahesh K. Jiwrajka, Ministry of Environment and Forests, New Delhi, India; Mr. Thanongdeth Insisiengmay, Mekong River Commission, Phnom Penh, Cambodia; and Professor Raj Pal Singh, University of Roorkee, Uttranchal, India.

Purpose: To attend the Flood Risk Assessment and Forecasting Workshop

Monday, December 2, 2002
(Training Room A unless otherwise noted)

9:00 a.m.	Welcome to United Nations Environment Programme (UNEP) / Global Resource Information Database (GRID) Background and Purpose of the Workshop (UNEP/GRID Work Room)	A. Singh
9:30 a.m.	Introduction of Participants (UNEP/GRID Work Room)	Delegates
10:00 a.m.	U. S. Geological Survey (USGS) / Earth Resources Observation System (EROS) Data Center (EDC) Briefing (Office of the Chief)	RJ Thompson
10:30 a.m.	Tour of EDC	R. Beck
11:30 a.m.	Lunch	
12:30 p.m.	Summary of UNEP study on Asian Flooding	H. Shi
1:30 p.m.	USGS International Program/Asia Flood Net (Science Department Conference Room)	J. Verdin S. Amer
3:15 p.m.	Break	
3:45 p.m.	Presentations by Workshop Participants	All
4:30 p.m.	Adjourn	

Tuesday, December 3, 2002

9:00 a.m.	Logistics	
10:00 a.m.	Introduction to ArcView	M. Budde
11:00 a.m.	FEWS Stream Flow Model (GeoSFM) Graphical User Interface (GUI) Introduction	G. Artan
12:00 p.m.	Lunch	
1:00 p.m.	FEWS GeoSFM GUI Model Input Data Preparation	G. Artan
3:00 p.m.	Break	
3:15 p.m.	GeoSFM calibration General Discussion on the Model	G. Artan
4:30 p.m.	Adjourn	

Wednesday, December 4, 2002

9:00 a.m.	Possible Future Collaborations and Summary (Front Half Conference Room)	J. Verdin A. Singh G. Fosnight
11:30 a.m.	Adjourn and depart for airport	

Thursday, December 5, 2002

(NOAA Silver Spring Metro Complex, Silver Spring, MD)

9:00 a.m.	Welcome to the Delegation	C. Barrett
9:15 a.m.	Organization of NOAA and the NWS	
9:45 a.m.	NWS Flood related Technologies	
10:30 a.m.	Break	
10:45 a.m.	NWS International Technology Transfer Projects	
11:15 a.m.	Questions and Answers, General Discussion	
11:45 a.m.	Adjourn	
12:00 a.m.	Lunch and Metro Transit to U. S. Agency for International Development (USAID)	
1:30 p.m.	Welcome to USAID (USAID Training Facility, 1201 Pennsylvania Avenue)	S. Tobar
1:45 p.m.	USAID Overview and Office of Foreign Disaster S. Assistance (OFDA) Asia Flood Net	S. Tobar
2:15 p.m.	State Department Transboundary Initiative	D. Deely
2:30 p.m.	Break	

2:45 p.m.	Presentations by selected Delegation members	
3:30 p.m.	General Discussion of Future Cooperation	
4:00 p.m.	Adjourn	
	Dinner in downtown Washington, DC – TBA	

Friday, December 6, 2002
(USGS, 12201 Sunrise Valley Drive, Reston, Virginia)

9:00 a.m.	Welcome to USGS Headquarters	A. Lenox
9:30 a.m.	Overview and Cooperative Water Program	J. Peters
10:00 a.m.	Surface-water data collection and reporting methods	R. Mason
11:00 a.m.	National Water Information System	C. Bostwick
12:00 p.m.	Lunch	
1:00 p.m.	Visit stream gaging station with real-time telemetry	W. Bartlett
4:00 p.m.	Adjourn	
	Dinner in Silver Spring, VA – TBA	

Distribution:

EDC Bulletin Board
Participants
Participants' Secretaries

G. Fosnight/jss/11-4-02

Appendix B
Gallery of Photographs

All participants (from left to right): Eugene A. Fosnight, Hua Shi, Raj Pal Singh, Mahesh K. Jiwrajka, Thanongdeth Insisiengmay, James Verdin, Zhiyu Liu, Ashbindu Singh, Yan Li, Saud Amer, Emaduddin Ahmad and Guleid Artan.

Discussion at office of UNEP/DEWA – North America, USGS, EROS Data Center, Sioux Falls, SD, USA.

Visit to the steam gauge site with real time satellite telemetry in Sterling, VA on 6 Dec. 2002

Appendix C
Contents of CD-ROM
(in order of presentation)

Monday, December 2, 2002

EROS Data Center: An Overview *presented by RJ. THOMPSON* (edcoverview short 12_02_02.ppt)

Early Warning, Forecasting and Operational Flood Risk Monitoring in Asia (Bangladesh, China and India) *presented by D.r SHI Hua* (UNEP Flood Report Summary.ppt & UNEP Flood Report.doc)

USGS International Program/Asia Flood Net *presented by Dr. J. Verdin* (FEWS Flood Model.ppt)

Flood Forecasting and Warning in China *presented by D.r LIU Zhiyu* (China flood risk forecast.ppt & China Flood Forecast & Warn.doc)

National Flood Forecasting System *presented by LI Yan* (China Flood Forecasting.doc & China Flood Forecasting.ppt)

Practices and Status of Flood Forecasting & Management in India *presented by Prof. Rajpal SINGH* (India Flood Forecasting.doc & India Flood Forecasting.ppt)

Mekong River Commission Flood Forecasting and Warning and Dissemination *presented by Thanongdeth INSISIENGMAY* (Mekong River Commission.ppt & Mekong River Warning System.doc)

Ongoing Initiatives on Flood Forecasting & Water Management in Bangladesh *presented by Emaduddin AHMAD* (Bangladesh-FFEW.doc & Bangladesh flood forecast.ppt)

Tuesday, December 3, 2002

Introduction to ArcView *presented by M. Budde* (ArcView Intro.ppt)Getting Data into ArcView *presented by M. Budde* (Getting Data into ArcView.ppt)

Displaying Themes ArcView *presented by M. Budde*) Displaying Themes ArcView.ppt)

Arcview Working with Tables *presented by M. Budde* (Working with Tables.ppt)

FEWS Stream Flow Model (GeoSFM) Graphical User Interface(GUI) Introduction *presented by G. Artan* (USGS/EDC/IP/SFM_Dec2002.ppt)

Wednesday, December 4, 2002

Summary meeting (Discussed above)

Thursday, December 5, 2002

Modernized Meteorological and Hydrologic Forecasting Technology *presented by Curt BARRETT* (NOAA NWS.ppt)

US Agency for International Development – Office of US Foreign Disaster Assistance *presented by Dr. Sezin Tokar and Dan Deely* (USAID/DCHA/OFDA/Water.ppt)

Friday, December 6, 2002

Cooperative Water Program *presented by James PETERS* (USGS/WRD Coop Fact Sheet.pdf)

NWISWeb: New Site for the Nation's Water Data *presented by Candace BOSTWICK* (USGS/WRD NWISWeb.pdf)

A Proposed Radar-Based Streamflow Measurement System for the San Joaquin River at Vernalis *presented by Robert Mason* (USGS/WRD vernalis.pdf)

Note: See Readme.doc file on CD for complete alphabetical list of contents.

Appendix D

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